Muelleria 9: 145–159 (1996)

A revision of the *Cardamine gunnii-lilacina* complex (Brassicaceae)

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ABSTRACT

Phenetic analysis of morphological variation in alpine and sub-alpine populations of *Cardamine* transplanted from the field and grown from seed resulted in the identification of two new species, *Cardamine franklinensis* I. Thomps. formerly included in *Cardamine gunnii* and *Cardamine robusta* I. Thomps., formerly included in *Cardamine lilacina*. Examination of herbarium material, field observations and growth trials resulted in the identification of a further new species, *Cardamine astoniae* I. Thomps., formerly included in *Cardamine lilacina*.

Introduction

Cardamine L. is a genus of about 200 species in the family Brassicaceae. The majority of species occur in temperate regions of northern and southern hemispheres. In Australia, a small number of endemic species are currently recognised, the majority of which are confined to south-eastern Australia, including Tasmania. They occur in moist habitats which include lowland swamps or watercourses, forests, sub-alpine woodlands and a variety of alpine habitats. Several introduced species have become naturalised in Australia and, although predominantly urban weeds, can occupy similar habitats to the native species.

Several Australian species in the genus *Rorippa* resemble Australian *Cardamine* and, until fairly recently, were placed in the latter genus. These taxa are still occasionally misidentified as *Cardamine*. They can be distinguished by several features including the shape of the replum (septum) margin of the siliqua which is flanged in *Cardamine* but not in *Rorippa*, seed morphology and the mechanism of dehiscence (in *Cardamine* this is explosive and results in the valves becoming coiled as they rapidly separate from the replum).

An account of Australian *Cardamine* in 1982 by Hewson (1982), although perhaps describing more of its diversity than previous flora treatments, failed to fully resolve its taxonomy. Her treatment of the *Cardamine gunnii-lilacina* complex (terrestrial, glabrous perennials with petals greater than 4 mm long) has created some uncertainty. Forms within this complex grow predominantly in higher altitude areas of south-eastern Australia and Tasmania. Hewson's key separates the two species as follows:

style up to 1 mm long - *C. gunnii*;
style 1-3 mm long - *C. lilacina.*

Style length refers to its length in the mature siliqua. Descriptions of the two species point to petal length as another means of distinguishing these species although the ranges for this character overlap. Petal length and style length, although useful characters, are unsatisfactory on their own for distinguishing forms within this complex. These characters vary within populations depending on season and stage of flowering and some populations have been found to have plants with style lengths ranging from less than 1 mm to more than 1 mm.

Hewson identified two informal variants of *C. gunnii*, one with pinnate and pinnatisect leaves with a large terminal ovate or reniform lobe, and the other with leaves entire-spathulate or pinnatisect with an elliptic to ovate terminal lobe. She identified four informal variants of *C. lilacina*, which vary in the dimensions of flower, fruit and seed and in the shape and number of leaf pinnae. She noted that variation was almost continuous and that further study was necessary to resolve this complex of variants. The

following study encompasses some of this variation and is based on live plant material collected from the field.

Materials and methods

Plants and seeds were collected in February and March, 1994 from six major regions (Fig. 1). Four in north-eastern Victoria (Mts Buffalo, Bogong, Nelse and near Mt. Hotham), one in south-eastern New South Wales (Kosciusko National Park) and one on the western border of the Australain Capital Territory (Brindabella Ranges). In most localities, especially in Victoria, populations were small and ripe fruits were present on only a few plants as the main flowering period is in November and December. Consequently, the number of plants removed for transplanting to pots was low in most cases and seed was collected from a small range of plants. Plants to be transplanted were maintained in plastic bags prior to potting up.

Two trials of alpine and sub-alpine plants were set up using the material collected from the field. A transplant trial containing 40 plants from 12 populations was established in February and March, 1994 by potting up the field-collected plants using a standard potting mix. The transplants were maintained outdoors over seven months and were subjected to Melbourne's climate. A seedling trial of 153 plants from 12 populations was established in April and May by germinating field-collected seeds in punnets in a heated glasshouse. For each population, seeds were derived from a variable number of parent plants ranging from one to four. In most cases, seeds germinated readily 7-21 days after sowing and germination rates approached 100%. Seedlings were transferred to 10 cm pots at the two-leaf stage and grown on in a heated glasshouse with pots arranged in a random-block design. Seedlings were also grown outside for comparison with the glasshouse-grown seedlings.

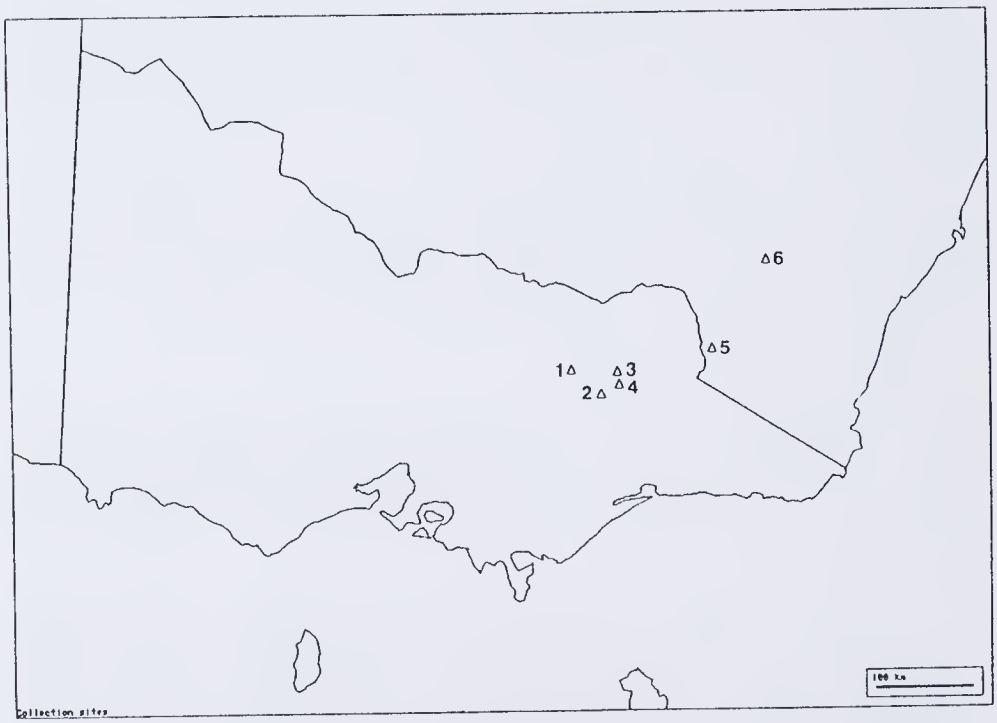

Fig. 1. Collection sites for alpine and sub-alpine *Cardamine* populations. 1. Mt Buffalo; 2. Mt Higginbotham; 3. Mt Bogong; 4. Mt Nelse; 5. Kosciusko Region (Blue Lake and Charlotte Pass); 6. Brindabella Ranges (Mt Franklin and Mt Gingera).

Herbarium material, from a greater range of collecting sites in south-eastern Australia, from SYD, CANB, CBG, MEL and MELU was also examined.

PHENETIC ANALYSIS

Nineteen vegetative and reproductive characters were used for the phenetic analysis of the transplants and twelve vegetative characters were used for the analysis of the seedlings (Table 1).

Morphological data from the seedling and transplant trials were phenetically analysed using the PATN package (Belbin, 1987). All data were range standardised. The Manhattan Metric (Williams, 1976) association measure was used to calculate a dissimilarity matrix.

Two agglomerative methods were used to produce an hierarchical classification: the Unweighted Pair-Group Method of Averages (UPGMA) and the Weighted Pair-Group Method of Averages (WPGMA). Dendrograms were produced using the DEND program and Cramer values were used to determine which characters best discriminated the final groups identified.

The dissimilarity matrix was also used in an ordination analysis. The KYSP program used Hybrid Multi-Dimensional Scaling (HMDS; Faith *et al.*, 1987) to produce a three dimensional ordination. The ordination with the lowest stress was selected from twenty iterations.

Results

The agglomerative classification of 40 transplants identified three main groups (Fig. 2), two consisting of individuals from single collection sites and the third consisting of individuals from a number of sites.

The three Blue Lake individuals (BL) were the most distinct, forming a cluster (group 1) that fused last in the classification (node a, Fig. 2). Two unique attributes distinguished the Blue Lake individuals. Firstly, vegetative stems of these plants elongate vertically as new leaves form, resulting in the rosette of leaves being held well above soil level, and secondly, inflorescence branches do not form from the axils of the cauline leaves as they do in the other transplants. Furthermore, Blue Lake plants have longer, and particularly broader petals than plants from other localities. Within the Blue Lake population, some variation occurred in petal shape, style length at anthesis and inflorescence architecture.

TABLE 1. LIST OF CHARACTERS FOR PHENETIC ANALYSIS OF TRANSPLANTS AND SEEDLINGS.

Transplant trial characters:	**Seedling trial characters:**
1. Petal length	1. Cotyledon lamina length
2. Petal width	2. Cotyledon lamina width
3. Style length at anthesis	3. Cotyledon lamina length to width ratio
4. Filament width	4. Cotyledon petiole length
5. Filament length to width ratio	5. Leaf number of first pinnate leaf
6. Sepal length	6. Leaf petiole width
7. Pedicel length at anthesis	7. Leaf length
8. Siliqua length	8. Maximum number of leaflets/leaf
9. Siliqua width	9. Cotyledon lamina margins recurved or not
10. Seed length	10. Cotyledon lamina surface plane or concave
11. Rosette leaves -maximum length	11. Terminal leaflet base cuneate or truncate-cordate
12. Rosette leaves - maximum no. of leaflets	12. Vegetative stem elongating or not

TABLE 1. CONTINUED.

Transplant trial characters:	Seedling trial characters:
13. Cauline leaves -no. per scape	
14. Rosette leaves terminal pinna cuneate or truncate-cordate	
15. Lateral pinnae sessile or not	
16. Projections from leaf rachis, present or absent	
17. Cauline 2° inflorescences, present or absent	
18. Flowers opening below, level with or above cluster of buds	
19. Vegetative stem elongating or not	

Plants collected from Mt. Franklin (FN, FS) clustered into two quite separate groups. Seven individuals formed group 2 (node b, Fig. 2, all from FN) and are distinct from all other transplants on the basis of leaf morphology. The terminal pinnae of basal leaves (laminae in the case of simple leaves) are elliptic and strongly cuneate at the base, and lateral pinnae, if present, are sessile (Fig. 5). All other individuals have basal leaves with terminal pinnae that are ovate to orbicular with a slightly cuneate to strongly cordate base and lateral pinnae that are petiolulate.

The remaining major group, group 3, clustered at node c of the dendrogram (Fig. 2). These transplants all form a rosette at soil level (as do group 2 plants), have leaves unlike those of group 2, and produce secondary inflorescences from the axils of their cauline leaves. Within this group further clustering was evident which corresponded closely with geographical distribution.

Five individuals from Mt Higginbotham, Victoria (HI) were distinguished by having erect pedicels and flowers that clearly overtop the buds in the same raceme. They also have broader siliquas than other plants in group 3. In four of these individuals, small, leafy triangular projections were present along the margins of the leaf rachis. This feature was not observed in other individuals. Eleven individuals from Mt Franklin (FS, FN) and three from Mt Gingera (GA) were similar; Mt Franklin plants differ, however, from those from Mt Gingera in having shorter basal leaves, fewer cauline leaves, narrower siliquas, smaller seeds, spreading pedicels and flowers opening well below the level of the buds in the same raceme. Mt Gingera individuals have flowers mostly opening at the same level as the buds.

Individuals from several Victorian populations, Mts Nelse (NE), Bogong (BO), Loch (LO) and Buffalo (BU), were similar to three Charlotte Pass (CP, NSW) individuals being short styled (mean 0.9 mm, style length measured at anthesis) and having small petals (mean~6.4 mm). This contrasts with the larger flowered plants from Mts Higginbotham, Franklin and Gingera. Charlotte Pass individuals have more slender staminal filaments and longer pedicels than the small-flowered Victorian populations.

A three-dimensional ordination of the 40 individuals is displayed in Figures 3 and 4. Clusters corresponding to the three groups identified in the classification are well separated and reasonably discrete. Clusters recognised within group 3 in the classification mostly do not overlap in the ordination but are less well separated than the major groups.

Only vegetative characters were available for analysis in the seedling trial. The results of a phenetic analysis of the seedlings generally supported the groups identified by the transplant trial. Vegetative stem elongation and shape of terminal pinna, two characters that helped characterise groups 1 and 2 in the transplant trial, also distinguished these groups in this trial. Petiole width distinguished Higginbotham and Franklin (larger-flowered populations in group 3 of the transplant trial) from Nelse,

Bogong, Buffalo and Charlotte Pass (smaller-flowered populations in group 3 of the transplant trial).

Discussion

Classification and ordination analyses of transplants, and classification analysis of seedlings, demonstrated a pattern of morphological variation of discrete forms such that the recognition of taxa is warranted. Examination of herbarium material of these forms further supports the results of the phenetic analyses.

The Blue Lake population (*Cardamine robusta* sp. nov.) is representative of one taxon (Fig. 2, group 1). Plants from this locality have distinct above-ground stem morphology, large flowers and do not form secondary inflorescences from cauline leaf axils. There are, however, differences within the population in floral and inflorescence morphology. Subsequent examination of underground parts of transplants showed this taxon to also have unique robust underground stems which ascend to produce new rosettes a variable distance from the parent rosette. This taxon has been informally recognised in the *Flora of Australia* as the robust, snow-patch variant of *C. lilacina* and as **species A2** in the *Flora of NSW* (Harden, 1991). The description of this variant in these floras does not, however, identify the above features.

Mt Franklin plants are recognisable as a second taxon (*Cardamine franklinensis* sp. nov.) on the basis of unique leaf morphology, that is, the combination of elliptic terminal pinnae and sessile lateral pinnae (Fig 2, group 2). This taxon has been informally recognised (Hewson, 1982) as the spathulate-leaved variant of *C. gunnii*. Non-spathulate-leaved populations conforming strictly to *C. gunnii*, as circumscribed by Hewson, were not collected. As noted in the introduction, the distinction between these forms and *C. lilacina* based on examination of herbarium material and Hewson's descriptions is not clear (see also notes under *C. franklinensis* below).

The remaining group constitutes a third taxon and is referrable to *C. lilacina* Hook. There is some evidence of discrete morphological variation within this group but low population sizes in the transplant trial and a limited seed diversity in the seedling trial disallows formal recognition of these discrete forms at this stage. For this complex to be fully assessed, comparisons need to be made with a greater range of populations of *C.*

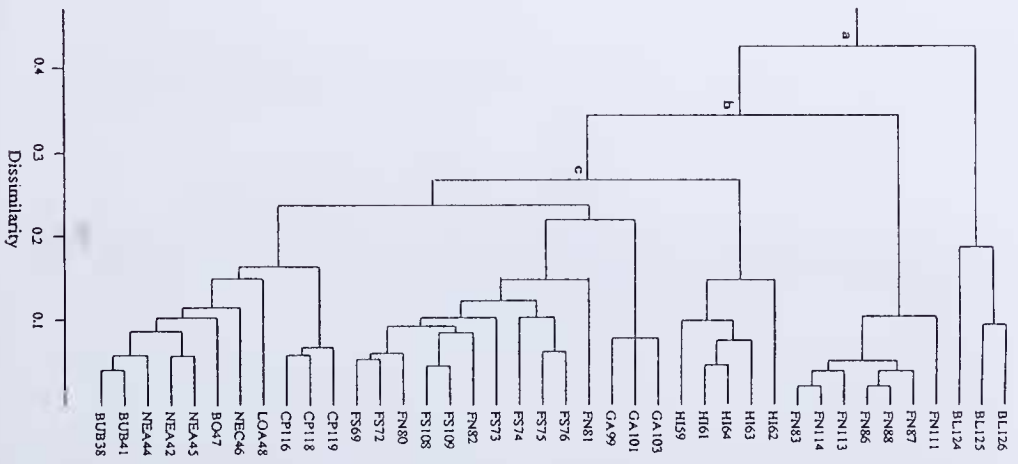

Fig. 2. Dendrogram showing results of cluster analysis of 40 alpine and sub-alpine transplants. Entire dendrogram shown (UPGMA fusion strategy). Group 1 locality - Blue Lake (BL); Group 2 locality - Mt. Franklin (FN); Group 3 localities - Mt. Buffalo (BU), Mt. Nelse(NE), Mt. Bogong(BO), Mt. Loch (LO), Mt Higginbotham (HI), Mt. Franklin (FS, FN), Mt. Gingera (GA), Charlotte Pass (CP).

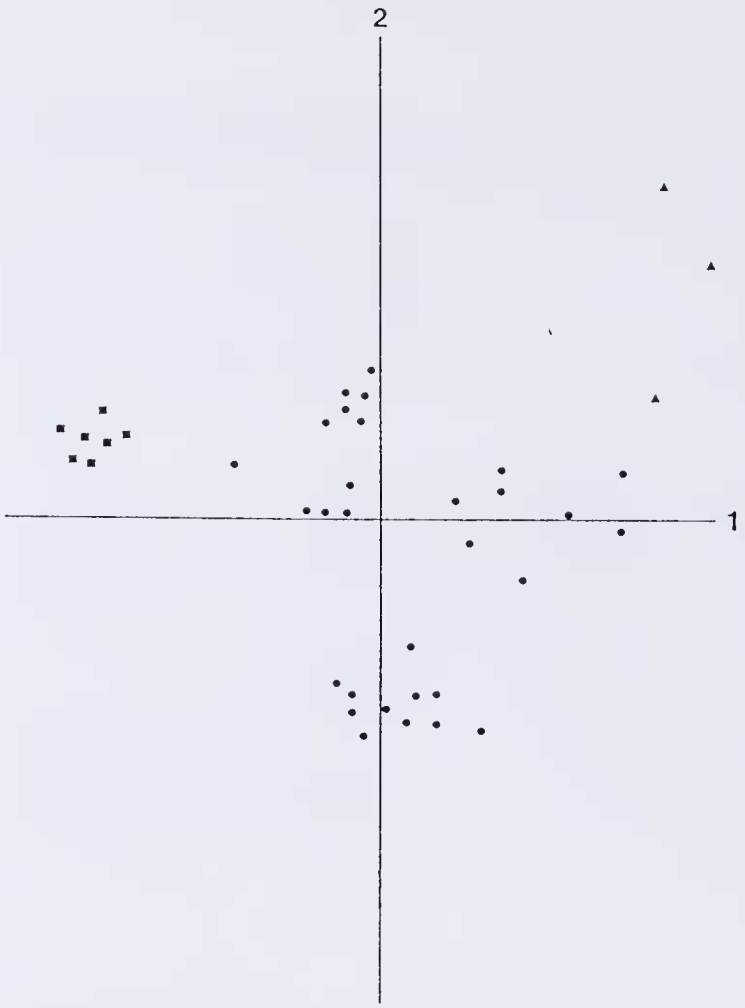

Fig. 3. Ordination of 40 transplants (Hybrid multi-dimensional scaling). Axes 1 and 2.▲ - Group 1 (Blue Lake) individuals; ▪ - Group 2 (Mt Franklin) individuals; • - Group 3 individuals.

lilacina and *C. gunnii*, in particular those occurring in lower altitude forests.

Chromosome counts from root tip squashes stained with lactoaceto-orcein indicated that the diploid number for each of these taxa was 48, although precise counts were not achieved. This number corresponds to counts by Thurling (1968) for higher altitude *Cardamine* in the Brindabella Ranges and Kosciusko area.

Subsequent to the phenetic analyses described above, field examination and growth trials of three alpine or sub-alpine *Cardamine* populations in Victoria and NSW, confirmed the existence of a new species, *C. astoniae* sp. nov. The existence of this species had been indicated by examination of herbarium records. This species is separable from *C. lilacina*, in which it was previously included, on the basis of stem and leaf characters. In the vegetative stage of growth above-ground stems grow horizontally and leaves do not form into a basal rosette. Leaves are usually simple or with only one pair of lateral pinnae. At flowering time the stem turns upwards to form a vertical scape.

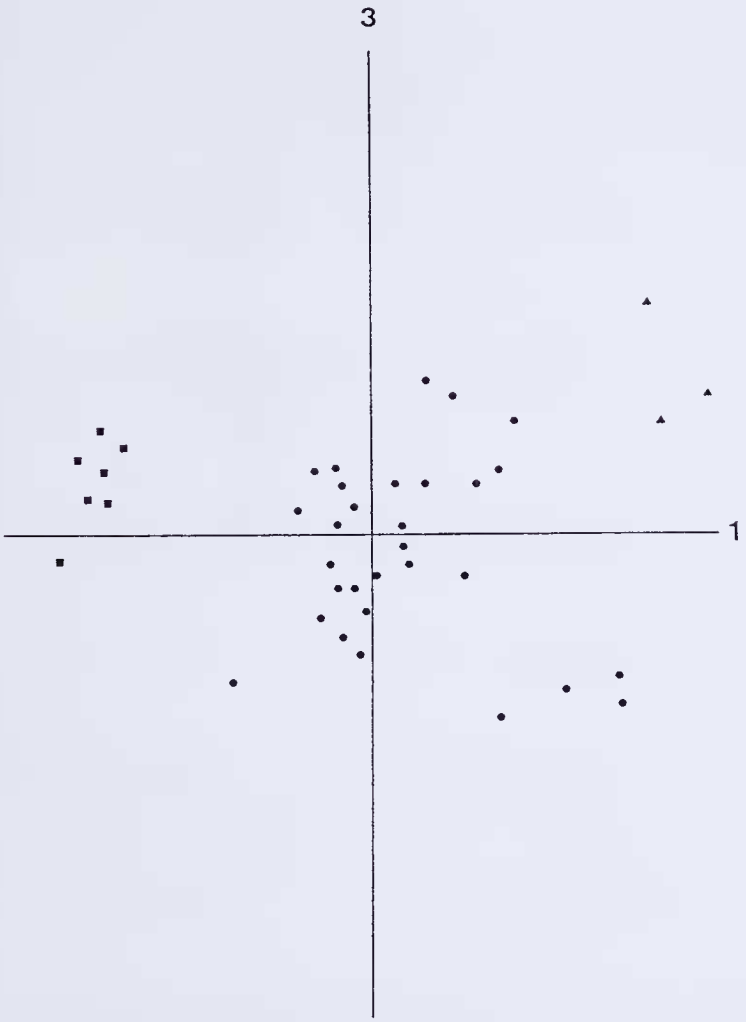

Fig. 4. Ordination of 40 transplants (Hybrid multi-dimensional scaling). Axes 1 and 2.▲ - Group 1 (Blue Lake) individuals; ▪ - Group 2 (Mt Franklin) individuals; • - Group 3 individuals.

Taxonomy

Cardamine robusta I.Thomps. *sp. nov.*

Cardamini lilacinae Hook. affinis, caulibus robustioribus, sobolibus robustis producentibus, caespitibus latis facientibus, foliis rosulae basibus aggregatis minoribus secus caulem, caule florenti simplici plerumque differt.

TYPUS: New South Wales, Club Lake, Kosciusko area 36°25'S, 148°16'E, 10 Jan. 1960, *B.G. Briggs* (HOLOTYPUS: NSW).

Perennial herb forming dense swards to c. 1m diameter, up to 30 cm tall, glabrous. *Roots* fibrous. *Vegetative stems* robust (3-10mm diameter), frequently branching above and below ground level, underground stems, white, growing more or less horizontally and then ascending to above ground level, above-ground stems of pressed specimens often wrinkled; flowering stem relatively slender and usually unbranched. *Leaves*

somewhat fleshy; basal leaves forming a rosette of erectly held leaves, the rosette usually distinctly above ground level and leaf bases somewhat loosely arranged along the stem, long petiolate, to 25 cm long, pinnate with 1-2(-3) pairs of lateral pinnae and a larger terminal pinna; terminal pinna broad-ovate to oblate the base cuneate to shallowly cordate, lateral pinnae similar in shape, long-petiolulate; cauline leaves 0-4, similar to basal leaves or much shorter and with pinnae becoming much narrower and more cuneate up the stem. *Inflorescences* few to many-flowered racemes, often condensed, sometimes more elongate. *Sepals* green, ovate, 3-4.5 mm long, petals broad, divided into limb and claw, 8-12 mm long, 5-7 mm wide, white; stamens 6; style at maturity 1-3 mm long. *Siliquas* 20-40 mm long, 2-3 mm wide on stout pedicels to 20 mm long. *Seeds* oblong-elliptic, 2-2.5 mm long. (Fig. 5)

DISTRIBUTION AND CONSERVATION STATUS

Cardamine robusta is endemic to alpine regions of the Kosciusko National Park in the Southern Tablelands of NSW and is recorded from several localities mostly associated with glacial lakes in this area, e.g. Blue Lake, Club Lake and Lake Albina. It does not appear to be threatened. (Fig. 6)

HABITAT

Cardamine robusta grows in alpine herbland/grasslands amongst granite boulders on moist slopes bordering glacial lakes, often bordering melting snow-patches.

ETYMOLOGY

The specific epithet of the new species refers to the vegetative stems which are more robust than in other native *Cardamine* species.

NOTES

Cardamine robusta has broad fruits and large seeds, similar to *C. astoniae* and higher altitude forms of *C. lilacina*. The development, in *C. robusta*, of thick underground stems to facilitate vegetative spread does not occur in these species although some vegetative spread can occur. In contrast to *C. lilacina*, secondary flowering stems are not normally produced from the axils of cauline leaves and typically racemes do not extend as far above the apices of the leaves (flowering often commences at or below the summit of the leaf mass). Petals are always white and large in *C. robusta*. Above ground vegetative stems are somewhat brittle when fresh and often are noticeably wrinkled following pressing. Basal leaves form a rosette with leaf bases relatively loosely arranged along a gradually elongating vegetative stem resulting in most basal leaves arising well clear of ground level. Leaves are often long and tend to be held fairly erectly. The propensity of *C. robusta* for vegetative spread means that broad and dense clumps up to c. 1 metre (or more?) in diameter can form. It flowers between January and April.

REPRESENTATIVE SPECIMENS (25 specimens examined)

NEW SOUTH WALES: Club Lake (Mt Kosciusko), 6200 ft, 20 Jan. 1951, *L.A.S. Johnson* (NSW); Lake Cootapatamba (Mt Kosciusko), 7 Jan. 1956, *M.E. Phillips* (NSW); Blue Lake, west bank (Mt Kosciusko) 21 Mar. 1971, *C. Totterdell* (NSW); 150 m downstream along Lady Northcote's Creek from Lake Albina, Kosciusko National Park, 6 Feb. 1993, *F.A. Zich 219* (NSW, MEL); Blue Lake, Southern Tablelands, 31 Jan. 1972, *I.R. Telford 3058* (CBG).

Cardamine franklinensis I.Thomps. *sp. nov.*

Cardamini lilacinae Hook. affinis, foliis simplicibus et spathulatis late, vel dissectis pinna terminali elliptica, pinnatis lateralibus in 1-2 paribus sessilis obovatis, seminibus parvioribus differt.

HOLOTYPUS: Australian Capital Territory, 2 miles [3.2 km] above Bendora on Mt Franklin Road, 13 Nov. 1953, *C.W.E. Moore 2777* (NSW).

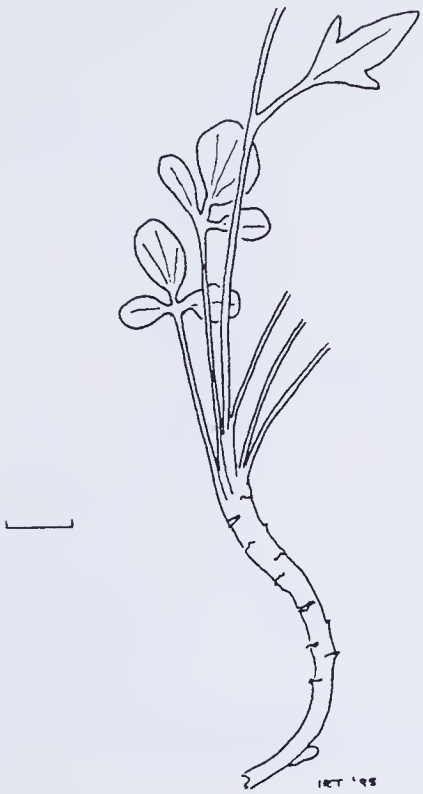

Fig 5. *Cardamine robusta*. Stem and leaves. From Briggs (NSW).

Perennial herb, to 30 cm tall, glabrous. *Tap-rooted. Stems* erect, usually branched from base and from cauline leaf axils. *Leaves* thin; basal leaves petiolate, to 15 cm long, simple or pinnate, mostly less than 7 cm long, forming an often dense persistent rosette; simple leaves entire to crenate, somewhat spathulate; pinnate leaves with an elliptic to ovate terminal pinna and 1-2 pairs of sessile, obovate, attenuate-based lateral pinnae; cauline leaves 0-3, reducing in size up the stem, lower ones sometimes similar to pinnate basal leaves, otherwise leaves simple, pinnatifid to entire. *Inflorescences* commonly many-flowered racemes. *Sepals* green or purple pigmented, ovate, 2-3 mm long; petals clearly divided into limb and claw, 4.5-6.5 mm long, all white or pink on the outside; stamens 6; mature style 1-2 mm long. *Siliquas* sub-erect, 25-35 mm long, 1.5-1.8 mm wide, pedicels erecto-patent c. 10 mm long. *Seeds* elliptic, 1.3-1.5 mm long. (Fig. 7)

DISTRIBUTION AND CONSERVATION STATUS

Cardamine franklinensis has been recorded from the Brindabella Ranges on the western boundary between Australian Capital Territory and New South Wales mostly in the vicinity of Mt Franklin, from Smiggin Holes in Mt Kosciusko National Park, from the eastern highlands of Victoria and from the central highlands in Tasmania. This species is not common and the only region from which there are multiple collections is the Brindabella ranges. The inconspicuous nature of the plant means that it is likely to be

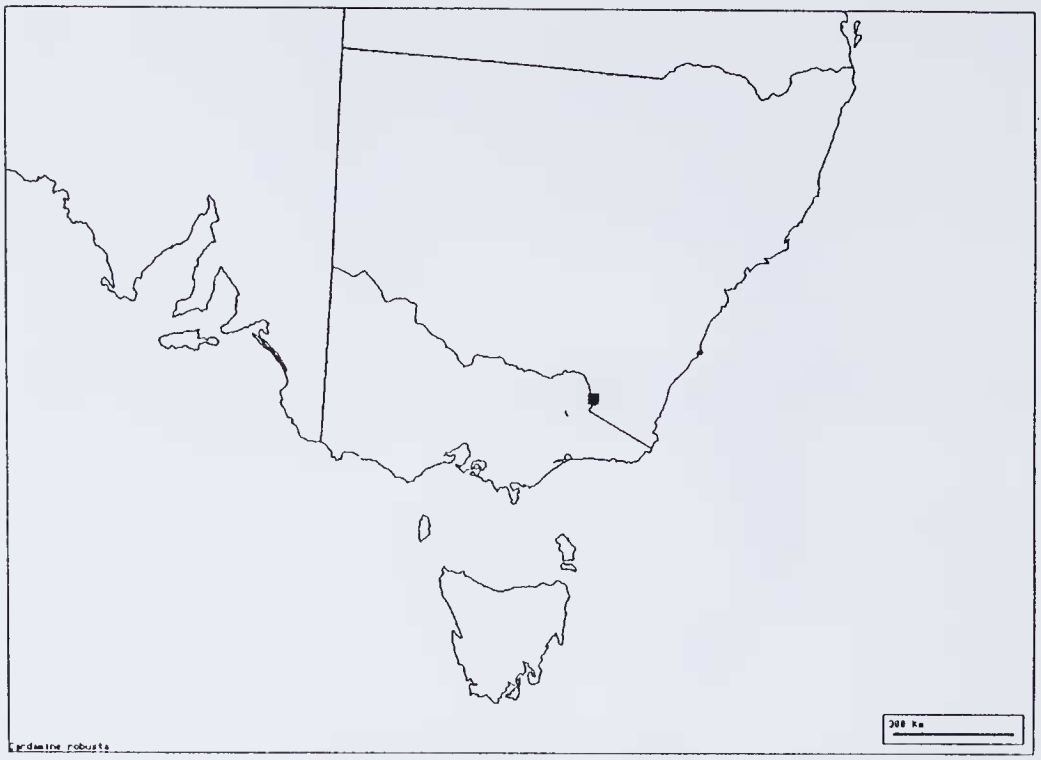

Fig. 6. Distribution of *Cardamine robusta*.

overlooked and may partly explain the small number of collections of this species. It is represented in Namadgi, Kosciusko and Alpine National Parks. (Fig. 8)

HABITAT

Cardamine franklinensis forms small colonies in sub-alpine woodland on rocky scree slopes or amongst *Poa* tussocks.

ETYMOLOGY

The specific epithet of the new species is named after the mountain (Mt Franklin) in the Brindabella ranges around which most collections of this species have been made.

NOTES

Cardamine franklinensis was formerly included in *C. gunnii* based on its petal size (between 4 and 6 mm long) and mature style length (less than 1 mm). In growth trials, however, the mature style of this species consistently exceeded 1 mm in length.

The lectotype of *C. gunnii* and several matching specimens on the same sheet have a distinctive root system with several sub-tuberous tapering roots arising from the base) and white petals 6-7 mm long. These are slightly longer than the often pink petals of *C. franklinensis*. *Cardamine gunnii sensu stricto* also has fewer basal leaves, different leaf morphology, (the terminal pinna of basal leaves mostly being triangular-ovate), is sometimes papillate and produces fewer-flowered racemes. It is thus appropriate to separate these two entities. Only one specimen of *C. gunnii s. str.* has been collected in the past 90 years, this a 1968 collection from Marsh's swamp near Mt Burr in south-east South Australia, although there are several nineteenth century collections from South Australia, Victoria and Tasmania. There is some doubt therefore as to whether *C. gunnii s. str.* is still in existence in Victoria and Tasmania. Locality information indicates that it occurs (or occurred) on lowland swamp margins and this further distinguishes it from *C. franklinensis*

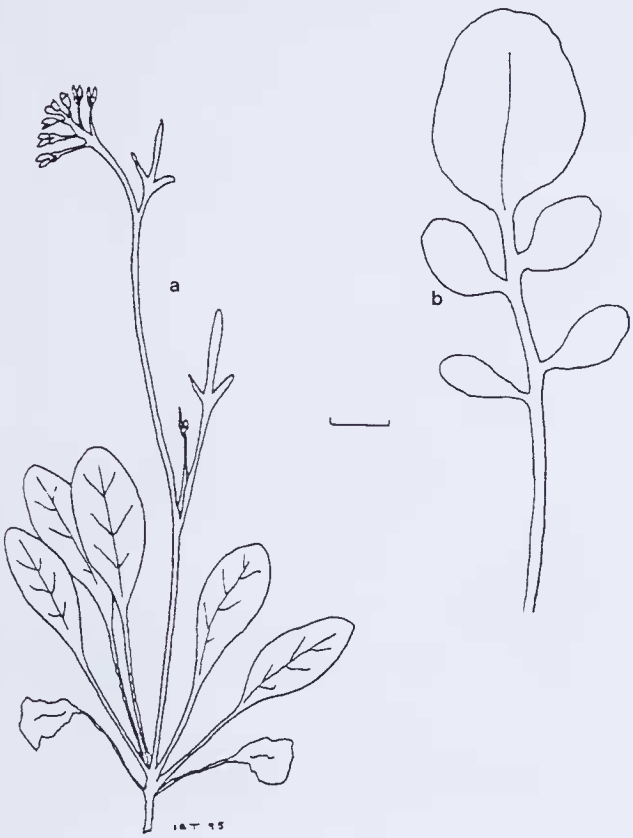

Fig. 7. *Cardamine franklinensis*. a - habit. b - basal leaf variant. a from *Burbidge 6692* (CBG), b from cultivated specimen.

Leaf morphology readily distinguishes *C. franklinensis* from the *C. lilacina* complex which is otherwise similar. Seeds of *C. franklinensis* are slightly smaller than the range for *C. lilacina* (1.5-3 mm long). Thurling (1968) seems to have included this entity in his breeding study of *Cardamine*. A population collected for this study (denoted as Race D) was described as entire-leaved (as *C. franklinensis* usually is) and it proved to be reproductively isolated from the other populations of *Cardamine* used in the trial, some of which are likely to have been *C. lilacina* based on collection site information.

REPRESENTATIVE SPECIMENS SEEN (12 specimens examined)

NEW SOUTH WALES: 2 miles [3.2 km] from Bendora on Mt. Franklin Road, 13 Nov. 1953, *C.W.E. Moore 2777* (NSW).

AUSTRALIAN CAPITAL TERRITORY: Eighty Acres, 6 km from Cotter River crossing at Cotter Flats towards Orroral Tracking Station, 2 Nov. 1976, *E.M. Canning 4116* (CBG); Brindabella Ranges 19.2 km from Picadilly Circus towards Mt Franklin, 1440 m., 29 Oct. 1986, *H. Thompson 767 and P. Ollerenshaw* (CBG).

VICTORIA: Bogong High Plains, near Wilkinson Lodge, 5400 feet, 6 Nov 1961, *T.B. Muir 2504* (MEL); Central Eastern Highlands, logging road c. 6 km NNE of Snowy Plains airstrip, Wonnangatta-Macalister R. divide, 1524 m, 7 Dec. 1970, *J.H. Willis* (MEL).

TASMANIA: Sandbanks Tier, 1280 m, 18 Mar. 1989, *A. Moscal 17292* (HO).

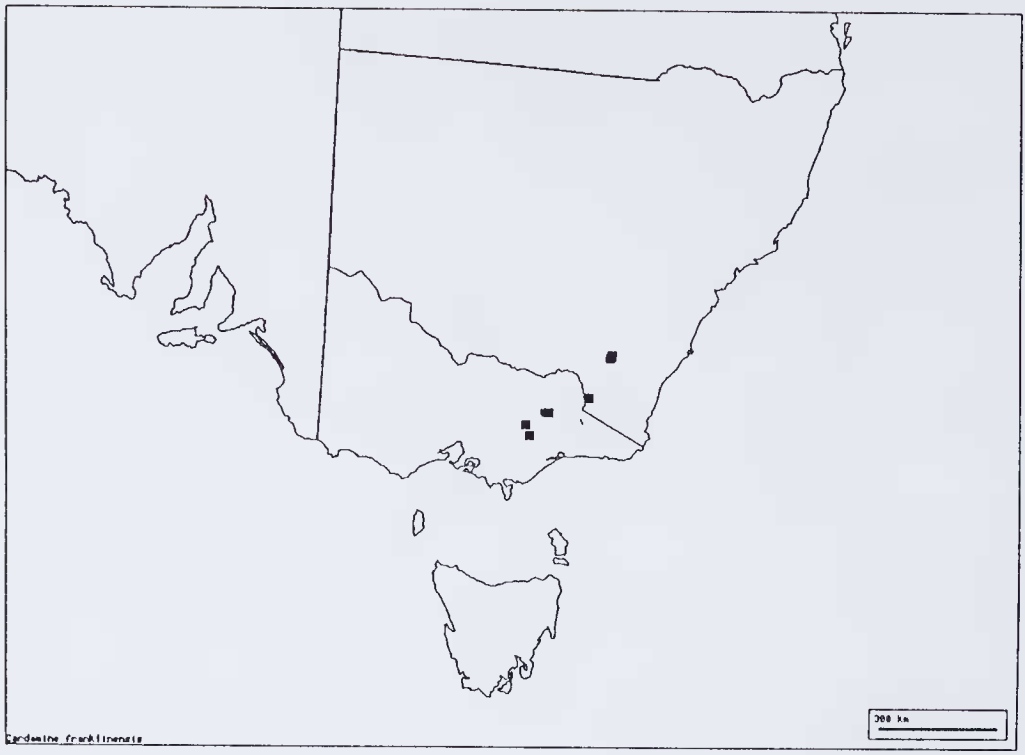

Fig. 8. Distribution of *Cardamine franklinensis*.

Cardamine astoniae I. Thomps., *sp. nov.*

Cardamini lilacinae Hook. affinis, caulibus stoloniferis, non rosulatis, foliis simplicibus vel pinnatis paucioribus differt.

HOLOTYPUS: Victoria, Snowfields, Bogong High Plains, between Rocky Valley Reservoir and Basalt Hill, Falls Creek area, 36°54'S, 147°18'E, 1650 m., 28 Dec. 1994, *Ian Thompson 84* (MEL).

Perennial herb, glabrous. *Roots* fine and fibrous. *Vegetative stems* long, growing horizontally, rooting at nodes, occasionally branching, turning upwards to produce an erect, usually unbranched flowering stem to c. 25 cm high. Leaves somewhat fleshy; basal leaves long-petiolate, simple or pinnate with 1-2 pinna pairs and a larger terminal pinna, to c. 15 cm long, mostly arising singly along vegetative stem, sometimes several clustered at base of flowering stem; terminal pinna ovate to elliptic, cuneate to cordate at the base; lateral pinnae orbicular to elliptic; cauline leaves usually several, pinnate to pinnatisect,the lateral lobes/pinnae angled strongly forwards. *Inflorescences* short many-flowered racemes. *Sepals* green, ovate, 3-4 mm long; petals broad, divided into limb and claw, 6-11 mm long, 3-6 mm wide, all white or pink on outside; stamens 6; mature style 1-3 mm long. *Siliquas* erect to sub-erect, 20-30 mm long, 2-2.5 mm wide; pedicels 10-20 mm long. *Seeds* oblong-elliptic, c. 2 mm long. (Fig. 9)

DISTRIBUTION AND CONSERVATION STATUS

Cardamine astoniae is recorded from several disjunct localities in Victoria, NSW and Tasmania. Areas include Barrington Tops National Park in the Northern Tablelands of NSW, the Southern Tablelands of NSW, several localities in the Alpine region of Victoria, notably Falls Creek and Mt Hotham areas, and from near Cradle Mountain in Tasmania. It is protected in National Parks. (Fig. 10)

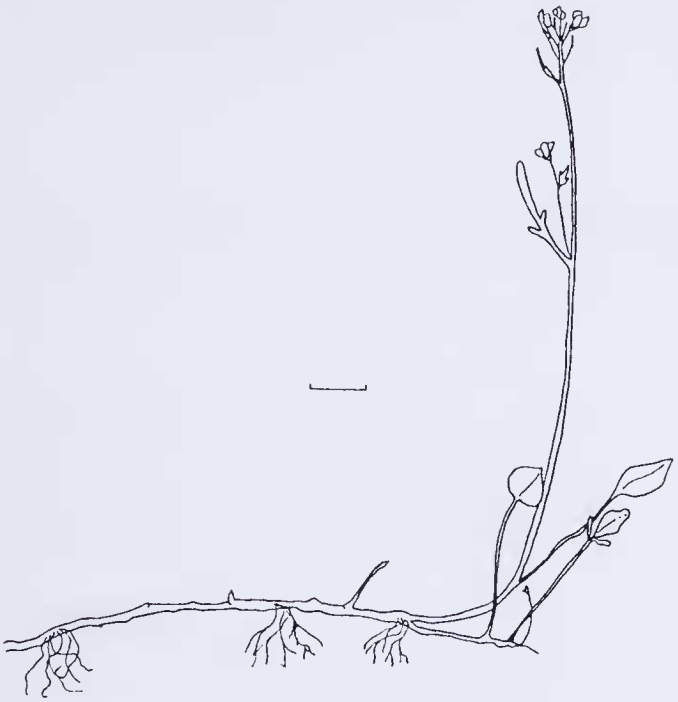

Fig. 9. *Cardamine astoniae*. Habit. From *Aston 182* (MEL).

HABITAT

Cardamine astoniae forms small to large colonies and grows amongst *Poa* or *Empodisma* tussocks in open, moist to boggy, alpine and sub-alpine environments.

ETYMOLOGY

Cardamine astoniae is named after Helen Aston, botanist and author of *Aquatic Plants in Australia*, who was the first to collect this species in Victoria.

NOTES

Cardamine astoniae has a distinctive habit which sets it apart from other larger-flowered species in Australia. It is inconspicuous when not in flower because it does not form a rosette of leaves. The horizontal stems grow through the litter layer with the lamina of the basal leaves just reaching above the level of the tussocks of grasses or rushes through which it creeps. The full extent of a single plant has not been ascertained but branches of the horizontal network of stems are up to 20 cm long. The flowers and fruits are similar to those of some larger-flowered alpine and sub-alpine populations of *C. lilacina* but the flowering stem is less commonly branched. The flowering period seems to be confined to late December and early January. Transplants from the field of *C. astoniae* maintain their horizontal growth habit.

REPRESENTATIVE SPECIMENS (16 specimens examined)

VICTORIA: N side of Mt Cope, Bogong High Plains, 1966, *A.C. Beauglehole 15508* (MEL); Timbarra R, Nunniong plateau, east Gippsland, 1964, *J.H. Willis* (MEL); At Pretty Valley, Bogong High Plains, 27 Dec. 1958, *H.I. Aston 182* (MEL); Bucketty Plain, *N.G. Walsh 3602* (MEL); Mt Loch 28 Dec. 1994, *I.R. Thompson 83* (MEL).

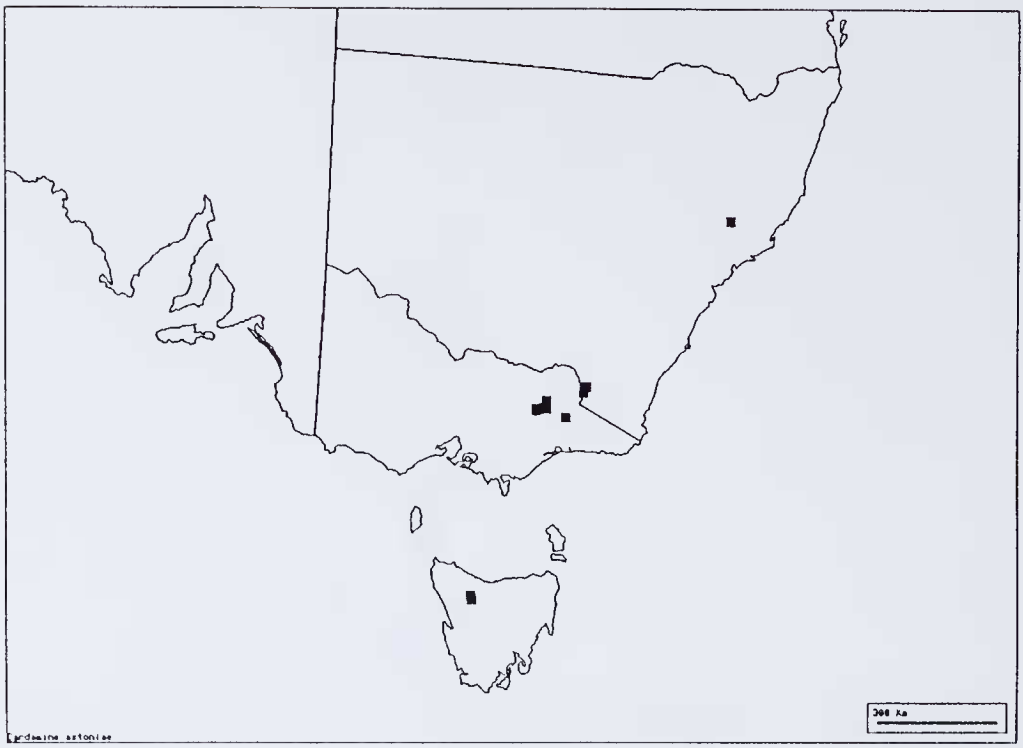

Fig. 10. Distribution of *Cardamine astoniae*.

NEW SOUTH WALES: S branch of Back Flat Creek, 0.25 mile [0.4 km] SE of Grey Mare Hut (upper Geehi R. district), 28 Dec. 1968, *A. Rodd 717* (NSW); Merritt's Creek, Kosciusko area, 10 Jan. 1960, *B.G. Briggs* (NSW); Saxby's Creek, 1 km NW of Carey's Peak, Barrington Tops, 29 Dec. 1969, *J. Pickard 821* (NSW).
TASMANIA: Leary's Corner, Middlesex plains, 17 Nov. 1986, *A. Moscal 13508* (HO).

KEY TO CARDAMINE GUNNII-LILACINA COMPLEX

The leaf blade of simple leaves is referred to here as the terminal pinna. The term pinna refers both to leaflets of pinnate leaves and to lobes of pinnatisect leaves when they resemble leaflets (i.e. if they are narrower towards the base).
Some species produce secondary inflorescences on flowering stems arising from the base of the primary stem or from cauline leaf axils. These inflorescences are typically fewer flowered than the primary inflorescence. In this key, the number of flowers per raceme refers to the primary inflorescence. Depauperate specimens will have fewer flowers per raceme.

1 Vegetative stems stoloniferous, basal leaves mostly arising singly at intervals along horizontal stem, the stem turning upwards to form an erect flowering stem ..... ***Cardamine astoniae***

1: Stems not stoloniferous, basal leaves forming a many-leaved rosette.....2

2 Plants spreading by means of robust underground stems which ascend to form new rosettes, bases of rosette leaves somewhat loosely arranged along stem, flowering stem simple, flowers large (petals greater than 8 mm long), white ..... ***Cardamine robusta***

2: Plants not spreading as above, bases of rosette leaves usually tightly clustered, flowering stem simple or branched, flowers variable in size (4-12 mm long), pink or white 3

3 Terminal pinna of basal leaves elliptic to ovate, cuneate at the base and lateral pinnae, if present, somewhat obovate, sessile and with attenuate bases, seeds 1.3-1.5 mm long, petals 4-6.5 mm long ..... ***Cardamine franklinensis***

3: Terminal pinna of basal leaves orbicular to ovate, often cordate at base, and most lateral pinnae distinctly stalked (petiolulate), seeds greater than 1.5 mm long, petals 4-12 mm long ..... ***Cardamine lilacina***

Acknowledgements

We are grateful to the National Herbarium of Victoria for the use of their facilities, to Neville Walsh of MEL for his assistance with the Latin diagnoses, to Dr. Tim Entwisle of MEL, and to Mali Moir for one of the accompanying illustrations. We are also grateful to the Directors/ Curators of AD, CANB, CBG, HO, K, MEL and NSW for the loan of specimens.

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Revised paper received 9 November 1995.